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Modernizing the Soviet Petrochemical Industry: Renewed Dependence on Western Technology

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A Research Paper

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A Research Paper

This paper was prepared by [] Office of
Soviet Analysis. Comments and queries are welcome
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**Modernizing the Soviet
Petrochemical Industry:
Renewed Dependence on
Western Technology**

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Key Judgments

*Information available
as of 1 February 1987
was used in this report.*

Modernization of the USSR's petrochemical industry—a key goal of Gorbachev's economic agenda—will require a substantial increase in acquisitions of Western technology and equipment:

- Because the rapid and successful development of the petrochemical industry during the 1960s and 1970s was based largely on Western equipment and technical services, advances in Soviet chemical engineering and research and development (R&D) waned during this period, and these sectors are now ill prepared to meet the industry's modernization needs.
- Eastern Europe will be unable to substantially fill the gap between the USSR's domestic equipment capabilities and its needs, largely because of the scale required and the East European countries' lack of capital and hard currency to modernize their own machinery plants.

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Because a modern petrochemical industry is crucial to advances in other key sectors of the economy—especially agriculture, machine building, medicine, construction, consumer goods, and transportation—the Soviets are likely to purchase from the West those items of technology and equipment most needed to modernize the industry. These include advanced equipment and technology to produce:

- Polymers for the production of modern plastics and synthetic fibers, which would increase the quality and quantity of consumer products and industrial materials.
- Sophisticated agrochemicals, which would boost agricultural yields and reduce costs.
- Membranes, which would improve quality and reduce the costs of processed foods, pharmaceuticals, and caustic soda.
- Catalysts, which would increase efficiency in oil refining and petrochemical production.
- Ammonia, which would reduce costs especially through energy savings.

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Financing such imports will be difficult, and the pace of acquisition is likely to be slow, given the hard currency constraints caused by the decline in earnings from energy exports and the increased competition from other sectors seeking Western assistance to meet modernization objectives.

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Nevertheless, we believe Moscow will try over the next few years to use some combination of cash, credits, compensation arrangements, and joint-venture agreements to acquire equipment and technology for most of these products.

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Moscow's dependence on Western petrochemical technology and equipment could provide opportunities for the United States to sell some of the needed items, notably technology for the production of herbicides and polymers. But there will be little or no opportunity to apply leverage because the Soviets can obtain what they need from most other Western countries and would probably treat the United States as a supplier of last resort if Washington tried to tie increased sales of technology and equipment to political or strategic concessions.

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Acquisition of Western technology and equipment would, at best, keep the technological gap with the West from widening further. Currently, the USSR's chemical technology is 10 to 20 years behind the West. The cost of closing this gap would be prohibitive and its duration protracted, given the relative backwardness of Soviet chemical engineering and the shortage of R&D personnel and skilled managers and workers. Declines in enrollments in the field of chemical science, as well as the continued drain of scientific personnel by the military, foreshadow continued shortages of professional and skilled labor for the industry.

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Substantial progress in modernizing the petrochemical industry will require sizable domestic investment as well as imports of machinery and equipment. Recognizing this, the Soviets plan to increase capital investment in the chemical and petrochemical industry by 50 percent during 1986-90 and to raise the share allocated for equipment by one-fourth compared with the previous five-year period. While much of this increase will go for imported equipment, we expect some increase in the supply of domestic petrochemical equipment as well. This will facilitate some improvement in automation and mechanization, and increase the output of fertilizers, plastics, and synthetic fibers currently being produced. Little has been said, however, about investing more heavily in training and education programs or channeling more resources into chemical engineering and R&D efforts. We expect some progress in these areas, but it will occur too slowly to have much impact before the mid-1990s.

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Moscow could boost the industry's efficiency in using new equipment by improving management and worker incentives. But implementation of managerial reforms in the chemical ministries and enterprises and changes needed in the organizational and incentive structure of the R&D system are likely to be resisted by the entrenched bureaucracy. Finally, the probable continuation of the unsuccessful competition with the military for corrosion-resistant metals will retard domestic production of chemical equipment. []

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Without Western help, therefore, the effort to modernize the industry would be seriously retarded, slowing modernization in practically all sectors of the Soviet economy. For example:

- Lack of success in supplying new technological processes and equipment would hinder efforts to conserve energy and raw materials.
 - A slowdown in the development of new materials, such as engineering plastics, would hold back advances in machine building, construction, and the automotive industry.
 - Inadequate supplies of sophisticated agricultural chemicals would retard growth in crop yields and jeopardize the goals of the Food Program.
- Even with Western help, as well as the planned increase in domestically produced investment goods, the pace of modernization will not be fast enough, nor the gains sufficiently widespread, to keep the USSR from having to continue playing technological catchup throughout the 1990s.

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Petrochemical Feedstocks, Products, and End Uses

<i>Feedstocks</i>	<i>Petrochemicals</i>	<i>Primary Petrochemical Intermediates</i>
<i>Natural gas</i>	<i>Unsaturates</i>	<i>Ethylene glycol</i>
<i>Methane</i>	<i>Ethylene</i>	<i>Ethylene oxide</i>
<i>Natural gas liquids</i>	<i>Propylene</i>	<i>Ethylene dichloride</i>
<i>(condensate)</i>	<i>Butylene</i>	<i>Vinyl chloride</i>
<i>Ethane</i>	<i>Butadiene</i>	<i>Acrylonitrile</i>
<i>Propane</i>	<i>Acetylene</i>	<i>Cyclohexane</i>
<i>Butanes</i>	<i>Aromatics</i>	<i>Ethylbenzene</i>
<i>Pentanes</i>	<i>Benzene</i>	<i>Styrene</i>
<i>Natural gasoline</i>	<i>Toluene</i>	<i>Phenol</i>
<i>Other petroleum liquids</i>	<i>Xylenes</i>	<i>Phthalic anhydride</i>
<i>Crude oil</i>	<i>Naphthalene</i>	<i>Terephthalic acid</i>
<i>Naphtha</i>	<i>Methanol</i>	
<i>Gas oil</i>	<i>Ammonia</i>	
<i>Raffinate</i>	<i>Carbon black</i>	
<i>Reformat</i>		

<i>End Products</i>	<i>Uses</i>
<i>Plastics (for example, polyethylene)</i>	<i>Coatings</i>
	<i>Packaging</i>
	<i>Plywood</i>
	<i>Paints</i>
	<i>Housewares</i>
<i>Syntetic fibers (for example, nylon)</i>	<i>Clothing</i>
	<i>Carpeting</i>
	<i>Upholstery</i>
	<i>Tire cord</i>
<i>Solvents (for example, acetone)</i>	<i>Dry cleaning fluids</i>
	<i>Personal care items</i>
	<i>Printing inks</i>
<i>Surfactants (for example, alkylarylsulfonate)</i>	<i>Soaps</i>
	<i>Detergents</i>
	<i>Industrial cleaners</i>
<i>Additives (for example, methyl tertiary butyl ether)</i>	<i>Antiknock gasolines</i>
<i>Synthetic rubber (for example, polybutadiene)</i>	<i>Lubricants</i>
	<i>Tires</i>
	<i>Belts and hoses</i>
	<i>Footwear</i>
<i>Fertilizers and pesticides</i>	<i>Agricultural production</i>

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Modernizing the Soviet Petrochemical Industry: Renewed Dependence on Western Technology

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The Role of Petrochemicals in the Economy

Petrochemicals have played a key role in technological advances in the Soviet economy over the last 25 years. They have been used to raise agricultural output, increase the longevity and efficiency of machinery, improve the technical characteristics of weapon systems, and reduce the cost and weight of construction materials. Petrochemicals have also expanded the selection and availability of food products, clothing, footwear, and medical and cultural services for the Soviet population (see inset).

In agriculture, the Soviets have been able to boost crop yields substantially since 1960 through increased use of fertilizers and pesticides. Chemical feed additives—which many Soviet livestock breeders believe are the cheapest means of getting more meat per unit of fodder—have helped increase meat output, and preservatives have maintained the nutritional value of natural feeds. In Soviet industry, chemical fibers are increasingly replacing natural fibers in tire cord and textiles. Petrochemicals are also used extensively in the energy sector to increase oil production, facilitate oil drilling and pipeline transportation, increase oil-refining efficiency, and extend motor fuel. Plastics are being used in machinery, precision instruments, and in the automotive, electronic, electrical, and communications industries, where their light weight, corrosion resistance, good insulation, and antifriction characteristics give them advantages over traditional materials such as metals, wood, paper, ceramics, and glass.¹ Soviet defense industries have also benefited from widespread application of engineering plastics in components for aircraft, submarines, missiles, and space vehicles.

¹ The Soviets claim that the use of 1 metric ton of certain kinds of plastics can replace 6 to 12 tons of alloyed steel, 6 to 10 tons of nonferrous metals, or 1.5 to 2 tons of aluminum. The production of these synthetic materials requires 2 to 3 times less energy than an equivalent amount of metal, and labor intensiveness in the manufacture of the majority of plastics averages 2.5 to 4 times less than that for metal products.

Despite the progress that Moscow has made in developing its petrochemical industry, the use of petrochemical products in the USSR lags that in Western countries. In 1984, with a GNP slightly more than 50 percent that of the United States, Soviet production of ethylene and propylene—major building blocks for many petrochemicals—was nearly double the output in 1975, but only 15 percent of US production. In the same year, Soviet production of plastics and synthetic fibers was one-third and one-fifth, respectively, that of the United States.

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Petrochemicals will have to play an increasingly important role in the Soviet economy if it is to become more advanced and sophisticated. The petrochemical industry will be called upon to supply increasing amounts, better quality, and a broader assortment of traditional products, as well as to develop new products. For example, the need to more efficiently extract and use nonrenewable resources such as nonferrous and ferrous metal ores, oil, gas, coal, and mineral chemicals will require an increase in the supply of flotation agents and other petrochemical products. Because of the sharp increase in the costs of extracting and processing fuels and ores, plastics will play an increasingly important role in replacing metals in machine-building, construction, and transport equipment. At the same time, the Soviets will have to deal with a consumer who is more attuned to what is available in the West and is less likely to be satisfied with a narrow range of low-quality consumer goods, including food products.

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The Development of the Industry

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In the late 1950s Khrushchev (like Gorbachev now) saw accelerated development of the chemical industry as integral to meeting the requirements of a modern industrial base, maintaining military parity with the

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West, and satisfying the ever-growing demands of the Soviet citizen for better foodstuffs and consumer durables. The Soviets believed that increased chemical production would make possible the substitution of synthetic materials for ferrous and nonferrous metals. With the savings derived from lower production costs, the leadership hoped to boost growth in industrial production. [redacted]

Khrushchev inaugurated a chemicalization drive in 1958 to accelerate development of the industry, particularly the production of synthetic materials. This program succeeded in rapidly increasing output of chemicals by infusing large amounts of capital and labor into the industry. The program increased the quantity and quality of chemical products available, but production of consumer-related chemicals was often well below plan, especially when compared to output of chemicals for heavy industry. Although the expansion of output was rapid, it was not particularly efficient because of the inability of the industry to effectively absorb the rapid infusion of new capital—much of which was of foreign origin. [redacted]

The Role of Western Equipment

Soviet efforts in the 1960s to develop improved processes or equipment for the production of a number of important petrochemicals—ammonia, acrylonitrile, caprolactam, polyethylene, and others—resulted in high-cost, relatively low-volume installations that were obsolete by world standards by the time they were commissioned. Failure of the domestic machine-building industry to supply state-of-the-art equipment and technology to produce petrochemicals forced the Soviets to turn to the West to meet expansion and modernization goals. [redacted]

During the 1970s Soviet orders of Western chemical equipment and technology—mostly for the production of petrochemicals—amounted to nearly \$9 billion, 30 percent of total machinery orders from the West (see table 1). Imports were concentrated on large-scale plants for the production of ammonia, urea, methanol, ethylene, plastics, synthetic fibers, and synthetic rubber (see figure). Most of the equipment and technology came from West European countries and Japan, because these countries supplied better credit terms and were viewed by the Soviets as more reliable suppliers than the United States. In 1981-85 the value

Table 1 Million US \$
USSR: Orders for Western Chemical Equipment

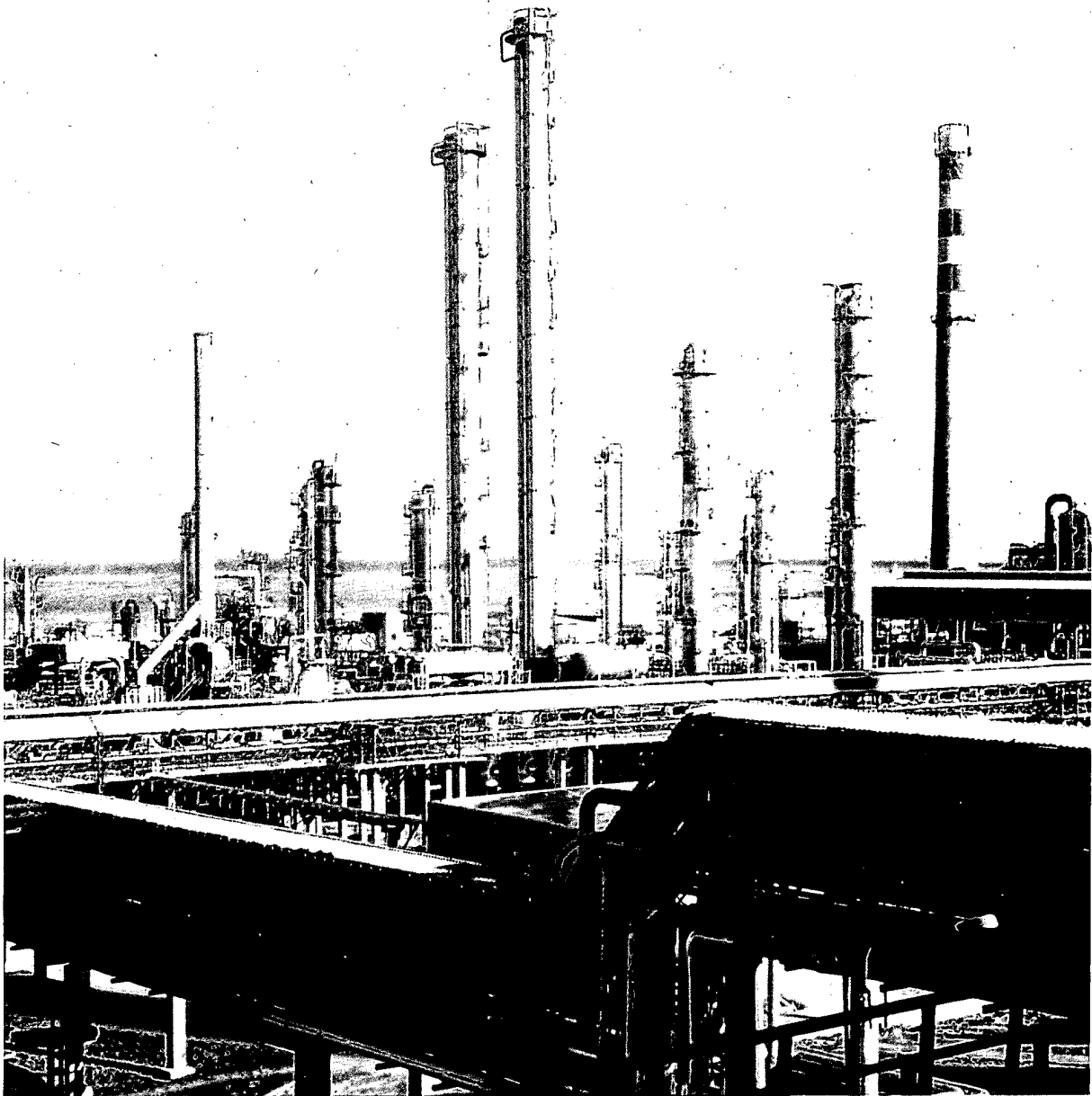
	1971-75	1976-80	1981-85
Total	3,632	5,268	1,719
By type:			
Agricultural chemicals and related equipment	1,534	1,766	558
Chemical fibers	715	697	307
Plastics and plastics-processing equipment	511	256	121
Rubber and rubber products	279	766	67
Other petrochemicals and related equipment	317	1,437	272
Other chemical equipment and technology	276	346	394
By country:			
France	799	1,207	323
Italy	959	713	125
Japan	446	1,302	167
United Kingdom	253	713	24
United States	520	141	42
West Germany	636	1,093	1,036
Other	19	99	2

of Western orders fell to \$1.7 billion, largely as a result of a shift in priority to imports of equipment for the oil and gas industries. [redacted]

With Western technology, Soviet output of ammonia and nitrogen fertilizers doubled in the 1970s. Large ammonia plants based at least in part on Western technology provided more than 90 percent of the new capacity introduced during this period. Western-equipped plants currently account for about 90 percent of polyethylene and polyester fiber capacity and about 50 percent of methanol capacity. The use of Western equipment and technology enabled the Soviets to realize savings from shorter plant construction times, more efficient production processes, and reduced or less costly inputs of raw materials, energy, and labor. For example, the Soviets claim that ammonia plants incorporating Western technology use only

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Western-supplied polyethylene plant at Budennovsk, USSR

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5 percent of the electricity and one-third or less workers per ton of output than older, Soviet-designed plants.

The Shift to Equipment From Eastern Europe

In the early 1980s, Moscow turned from the West to its East European allies for a much larger share of equipment imports. By 1985 East European countries

were providing more than one-half of Soviet imports of chemical equipment. Despite growing capabilities to supply certain types of chemical equipment and related technology, Eastern Europe has not been able to fill the gap between Soviet production and requirements. Nevertheless, equipment supplied by East

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European countries has helped boost production of selected petrochemical products. Czechoslovakia generally has replaced Western countries as a source of urea and ethylene plants. In recent years, the Soviets have ordered 12 urea plants from Czechoslovakia. The 300,000-ton-per-year ethylene plants now being built in the USSR are based on a Czechoslovak reforming process and use Czechoslovak pyrolysis furnaces. East Germany has supplied plants for producing alcohols, nylon, and polyvinyl chloride. The Soviets are also building low-density polyethylene plants based on a process developed jointly with the East Germans. Hungary supplies a variety of rubber and plastics-processing equipment that the Soviets would probably have otherwise purchased from the West. [redacted]

The Payoff: Progress and Problems

Increased Production From Foreign Equipment . . . Major Soviet investments in foreign (especially Western) equipment and technology have paid off in terms of rapidly increasing volume and assortment of output over the last decade (see table 2). Just as important, the structure of production changed to favor the output of more advanced polymerization plastics such as polyethylene, polypropylene, polyvinyl chloride, and polystyrene. These products—which accounted for nearly one-half of total plastics output in 1984—led to improvements in packaging, film, pipe, molded items for homes and automobiles, cable coatings, electric insulation, and construction components. At the same time, the share of high-grade synthetic fibers (polyamide, polyester, polyacrylonitrile)—used to supplement and replace natural materials in clothing, carpets, tire cord, and hoses—reached 54 percent of overall output of chemical fibers.² Production of high-grade synthetic rubber (polyisoprene and polybutadiene) also increased. [redacted]

The growth in output also enabled Moscow to increase its hard currency earnings from exports of chemical products. Hard currency earnings from chemical exports amounted to about \$1 billion in 1985, of which at least one-half were petrochemicals

² Chemical fibers include *artificial fibers* generally derived from cellulose, such as rayon, and *synthetic fibers* made from polymers derived from oil or natural gas, such as nylon and polyester. [redacted]

Table 2 *Million metric tons*
USSR: Production of Selected Petrochemical Products

	1975	1980	1981	1982	1983	1984	1985
Intermediate products							
Ammonia	12.0	16.7	17.9	17.8	20.6	21.5	22.2
Methanol	1.4	1.9	2.0	2.0	2.2	2.5	2.8
Benzene	1.4	1.6	1.7	1.7	1.9	2.0	NA
Xylenes	0.3	0.5	0.5	0.4	0.6	0.8	NA
Ethylene	1.4	1.8	2.0	2.1	2.3	2.5	2.7
Finished products							
Plastics	2.8	3.6	4.1	4.1	4.4	4.8	5.0
Synthetic fibers	0.3	0.6	0.6	0.7	0.7	0.7	0.8
Nitrogen fertilizers (100-percent nutrient equivalent)	8.5	10.2	10.7	11.6	13.0	13.3	14.2

Source: *Narodnoye khozyaystvo SSSR and Statisticheskii yezhegodnik stran-chlenov soveta ekonomicheskoy vzaimopomoshchi*, various years.

[redacted]

(see table 3). Major Western buyers have been the United States, West Germany, the Netherlands, and Italy. [redacted]

. . . But Domestic Technology Lagging. At the same time that the petrochemical industry was posting substantial gains by relying largely on Western technology, Soviet domestic chemical equipment industries were allowed to languish and are now ill prepared to produce advanced equipment for further modernization. Moreover, the organization of research and development (R&D) for both new equipment and products is inefficient. Compared with the West, the Soviets take an excessive amount of time to go from development to production. The time from R&D to production in the Soviet chemical industry is often 10 to 15 years for major projects. In late 1985 only 400 of 1,200 chemical industry innovations available in 1981 had been applied. Furthermore, plans for

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Table 3
USSR: Exports of Selected
Petrochemical Products
for Hard Currency

Million US \$

	1975	1980	1981	1982	1983	1984	1985
Ammonia	8	290	377	251	325	413	307
Nitrogen fertilizers	143	211	286	257	213	252	123
Plastics and materials for plastics production	18	69	67	79	90	94	94
Xylenes	8	7	2	2	22	93	115
Methanol	5	19	19	13	7	23	57
Toluene	10	41	26	21	28	25	17

Source: *Vneshnyaya torgovlya SSSR*, various years.

R&D generally are not coordinated with plans for the design, construction, and renovation of enterprises. In addition to poor domestically produced equipment and inefficient R&D, the petrochemical industry is plagued by slow construction and underutilized capacity (see inset).

Moreover, the USSR—a net importer of chemicals—is still dependent on Western sources for some critical petrochemical products. In 1985 petrochemical imports from the West amounted to about \$1.5 billion and included synthetic fibers, plastics, dyes, pesticides, and rubber and textile chemicals. Although Moscow relies on the West for only 7 percent of overall plastics consumption, imported products include the more advanced types of materials that the Soviets either do not produce at all or produce in only limited quantities. They also import pesticides because of inadequate domestic supply, and they do not plan to produce some of the more modern pesticides. The Soviets believe that it is cheaper for the West to do the pesticide R&D for them and that there is no advantage in building the necessary intermediate plants for which they would have no other use. Although East European countries are supplying increasing quantities of petrochemicals to the USSR, the Soviets will have to continue to rely on the West for many of the more sophisticated products.

Soviet Policy for Modernizing the Petrochemical Industry

Gorbachev clearly views accelerated growth in the petrochemical industry as crucial to progress in other key sectors of the economy. Major progress in modernization of the petrochemical industry could raise the production effectiveness of practically all sectors of the economy, result in increased yield potential of agricultural crops, free sizable amounts of metal for other purposes, save energy, and better protect metals, wood, and other materials. In his speech at the Science and Technology Conference in June 1985, Gorbachev called the chemicalization of the national economy “an urgent demand of our time.” Complaining that many research institutes are isolated from production facilities, he stated:

The Ministry of the Chemical Industry is overgrown with a multitude of various scientific establishments and experimental production facilities. But it is in that industry that major shortcomings have been uncovered in the development of new materials and technologies.

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At Dnepropetrovsk, in June 1985, he noted that the chemical industry is linked to the development of strategically important branches of the economy that determine scientific-technical progress such as machine building, electronics, electrical engineering, and biotechnology.

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Underscoring the importance Gorbachev attaches to the chemical and petrochemical industry, the CPSU Central Committee announced in October 1985 a comprehensive program for the chemicalization of the Soviet economy up to the year 2000, most of which applies to the petrochemical industry. The program calls for:

- Accelerated output of plastics, chemical fibers, consumer and household products, small-tonnage chemicals, and substitutes for food products now used in chemical manufacturing.³

³ Small-tonnage chemicals are those that are produced in small quantities, such as dyes, catalysts, and high-purity compounds. Food products include vegetable oils used in paint and varnishes.

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Problems in the Petrochemical Industry

Although the average annual inventory of unfinished construction in the chemical and petrochemical industry decreased 18 percent in 1981-85 compared with 1976-80, construction lags still present a problem. During 1981-85, annual plans for construction of chemical industry facilities were progressively reduced compared with the goals of the original five-year plan. Delays were caused by poor design documentation, inadequate labor and material resources for the large number of projects, and inadequate funding. Deliveries of equipment were frequently late, and, when the machinery did arrive, it was often incomplete.^a Moreover, uncoordinated completion times of related plants have often resulted in downstream facilities for which there is no feedstock or, conversely, plants producing feedstock for which there are no downstream installations. []

With the current emphasis on large-capacity petrochemical plants, the technological and equipment problems and the resulting idle capacity are causing much larger shortfalls in production than in the past. Moreover, assimilation of imported advanced petrochemical technology continues to be hampered by improper handling and installation of machinery, maintenance problems, and difficulties in mastering new production processes. In addition, poorly manufactured domestic petrochemical equipment—which is often outmoded, lacks corrosion resistance, and wears out prematurely—causes many petrochemical plants to operate below rated capacity. The Soviets claim that many plants producing polyvinyl chloride, ammonia, and ethylene generally operate at 75 to 85 percent of capacity. []

^a For example, a Western-supplied insecticide plant, scheduled for 1983 completion, was only recently started up at Navoi in Uzbekistan. Delays were caused by poor construction, inadequate training of technicians, and lack of equipment and quality metal. []

Inadequate and poor-quality supplies and irregular deliveries of feedstocks also contribute to underutilized production facilities. Because of inadequate storage facilities, supplies of natural gas are often diverted to residential heating during severe winter weather, causing shortfalls in production of ammonia and methanol. Failure to deliver crude oil results in underutilization of oil refineries and downstream petrochemical plants. Shortages of intermediate petrochemicals cause below-capacity operation and temporary shutdowns of facilities producing plastics, synthetic fibers, and synthetic rubber. Feedstock shortages have been hampering production at petrochemical plants in the Volga-Urals region, for example, where the output of associated gas has fallen as a result of declining oil production in that area. According to the Soviet press, the Shevchenko plastics plant in Kazakhstan is experiencing serious feedstock shortages because the local gas plant, faced with lower associated gas supplies, cannot supply enough ethane for ethylene manufacture. []

To run efficiently, large-capacity petrochemical plants require highly trained workers. Past failure to meet the industry's demands for skilled labor has caused improper use of equipment, poor maintenance, and idled capacity. The Soviets reported that an ethylene plant at Angarsk, for example, was late in starting operation, because, of the 250 skilled workers needed, only 50 were available and only two were capable of startup work. []

Shortages of railroad cars, especially tank cars, hamper deliveries of raw materials and intermediate products, frequently causing temporary shutdowns or below-capacity operations. Shortages of specialized cars for finished petrochemical products such as nitrogen fertilizers compel the industry to ship large quantities in bulk in boxcars and even in open gondola cars, resulting in losses. []

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- A 70-percent increase in consumer goods production in 1990 compared with 1985.
- A step-up in the substitution of chemical for natural fibers in industrial applications.
- More intensive cooperation with CEMA countries in the production and reciprocal deliveries of chemical products, equipment, and raw and intermediate materials.
- Construction of production facilities for high-quality chemical products that will be competitive in world markets.
- Introduction of additional capacity, a step-up in development of highly efficient technological processes, reconstruction and reequipping of existing enterprises, automation and mechanization of production processes, and improvements in the quality and variety of chemical products. [redacted]

Production increases called for in the Chemicalization Program imply an overall average annual growth rate in output of all chemical products of about 5 1/2 percent in 1986-90, similar to that achieved in 1981-85, while growth rates in 1991-2000 will be somewhat lower (see table 4). Priority will be given in the early stages of the program to increased chemicalization of agriculture and the production of products for consumer goods and services. Special attention also will be given to products that support the Long-Term Energy Program, such as surfactants and anticorrosion chemicals used to increase oil production, and chemical additives used to enhance the performance of refined oil products. As a move to conserve resources, output of recyclable polymer packaging is scheduled to triple. Most of the planned increases in output are scheduled to come from gains in labor productivity. The share of chemical production in total industrial output is to be increased to 8 percent by 1990, compared with an average of about 6.5 percent in 1981-85. [redacted]

Gorbachev's strategy includes restructuring investment aimed at improving chemical and petrochemical machine building. It is hoped that this restructuring can supply the industry with sufficient quantities of

Table 4
USSR: Output Goals of the Chemicalization Program ^a

	1981-85	1986-90	1991-2000
Synthetic resins and plastics	6.7	6.3-7.3	6.0
Chemical fibers	3.5	5.7	4.2
Chemical fertilizers	6.0	4.3-5.3	3.0
Pesticides	4.1	4.3-6.1	NA
Caustic soda	2.1	NA	3.2

Source: Foreign Broadcast Information Service, *Daily Report, Soviet Union*, 17 December 1985.

^a Average annual growth rate in percent.

[redacted]

high-quality modern equipment to reduce dependence on the West. In support of the petrochemical industry, Gorbachev is also calling on domestic machine builders to increase output of large-scale modular chemical equipment by 30 to 50 percent. A deputy chairman of the State Planning Committee stated in late 1985 that only machinery that ensures an increase in labor productivity of at least 50 to 100 percent, reductions of metal inputs per unit of output of at least 7 to 10 percent, and energy savings of 8 to 12 percent was to be included in the machine-building production goals of the 1986 plan. By supplying new machines and technologies, retooling existing enterprises, and increasing the retirement of obsolete machinery, Gorbachev hopes to increase the output and quality of petrochemical products. [redacted]

Gorbachev also plans to revitalize management and planning and put more control in the hands of the enterprise managers. These steps could be an important factor in helping the petrochemical industry overcome traditional inter- and intra-sectoral imbalances in the supply of raw and intermediate materials. In 1985 Gorbachev included the Ministry of Chemical and Petroleum Machine Building in the experiment in industrial management and, in 1986, added

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the Ministries of the Chemical Industry, Mineral Fertilizer Production, and Petroleum Refining and Petrochemical Industry. This scheme includes penalties for delays, nondelivery, or delivery of inferior goods, as well as rewards for the timely supply of satisfactory products. Such measures could help reduce some of the bottlenecks associated with the supply of petrochemicals and petrochemical equipment and improve the quality of these products.⁴ Gorbachev also hopes that improved discipline, along with a system of rewards that clearly favors productive workers and managers, will increase labor productivity. To the extent that this stimulates more and better production of plastics, fibers, and synthetic rubber, the additional output could be used to bolster the availability of more high-quality consumer goods and, in turn, boost worker morale. []

Gorbachev has backed up his administrative measures by installing a new cadre of managers at the helm of the chemical and petrochemical industries. He replaced the Minister of the Petroleum Refining and Petrochemical Industry in 1985 and the Ministers of the Chemical Industry and Chemical and Petroleum Machine Building in 1986. The new Minister of the Petroleum Refining and Petrochemical Industry, Nikolay Lemayev, has longstanding experience in the petrochemical industry as a manager. Under his direction the Soviets successfully installed and operated Western equipment and technology at the vast Nizhnekamsk petrochemical complex. The new Minister of Chemical and Petroleum Machine Building, Vladimir Luk'yanenko, was a successful director of a machinery plant in Sumy and more recently the head of a national compressor institute. The new Minister of the Chemical Industry, Yuriy Besspalov, has many years of experience in the chemical industry. []

Viability of the Modernization Program

To make its program work successfully, we believe the leadership will need to carefully balance its investment and manpower allocations, machinery and technology imports from both East and West, and changes

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in management and incentive systems. Although some short-term gains in output can be achieved through managerial reform and tighter discipline, long-term advances in technology and quality will depend on more fundamental changes in incentives and resource allocations that:

- Encourage innovation and technical progress.
- Reduce the military's preemption of scarce R&D resources (including skilled manpower and high-technology products).
- Remove the barriers between research institutes and production enterprises. []

Although imported Western technology enabled the Soviets to develop their petrochemical industry much sooner than if they had relied on domestic sources, much of the equipment imported from the West has now been in operation 10 to 20 years and needs replacement if the USSR is to keep pace with Western technological advances. For example, the development in the West of linear low-density polyethylene has resulted in energy savings and a stronger product than low-density polyethylene. Although the Soviets are producing large quantities of bulk petrochemicals, they also need technologies for a new generation of sophisticated materials such as composites, engineering plastics, membranes, and catalysts. Because the petrochemical industry is central to the modernization of other industries and is a strategic industry that supplies materials for the military, further technological gains are vital to the economy. []

The USSR has been relatively successful in the development of some basic technologies, such as those for synthetic rubber and ammonia (see inset). But the Soviets still have much to accomplish in developing advanced technologies. They need to develop the flexibility to produce small-tonnage chemicals more efficiently and to broaden and upgrade automated control systems in the petrochemical industry. Plant managers especially need electronic information networks and inventory control systems to alleviate inter- and intra-sectoral imbalances of raw materials, intermediate petrochemicals, and finished products. Although much of the petrochemical industry is automated to some extent, many Soviet control systems

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Technological Capabilities of the Petrochemical Industry

Recognizing the strategic necessity to produce their own rubber, the Soviets established as one of their highest priorities the reduction and eventual elimination of imports of natural rubber. The construction in the 1970s of large polyisoprene rubber plants based on Soviet technology increased output and has been the primary reason that the USSR has been able to reduce imports of natural rubber. Nevertheless, the Soviets have relied on the West for technology and equipment for the production of special-purpose rubbers such as chloroprene and butyl rubber as well as drying and processing equipment. Although the Soviets have a process for the dehydrogenation of butane to butadiene—an intermediate petrochemical used to produce synthetic rubber—they have ordered three large-scale plants from the West because the Western process uses less energy and equipment.

In the case of ammonia, the USSR apparently could not develop technology and equipment for large-capacity plants fast enough to meet its projected goals and in the early 1960s began to seek foreign technology. The Soviets claimed to have developed a process for large-capacity ammonia production in 1968 but continued to purchase foreign large-capacity plants until the late 1970s. Nevertheless, Soviet engineers are beginning to assimilate and integrate some imported technology into the domestic industry. The USSR developed its first large-capacity ammonia process using imported technology and certain domestic equipment. Moscow is now building ammonia plants using its own technology, and in 1985 four domestically produced plants began operation. The Soviets also claim to have developed a new technology for ammonia production that requires much less metal and energy. Prototypes of the new equipment have been tested, and several units are scheduled to be brought on line in 1986-90.

are primitive compared with those in the West. The Minister of the Chemical Industry reported that, by the end of 1985, three-fourths of the industry's output was to come from factories equipped with automated control systems. But the potential of automated process control is hampered by the same kinds of problems plaguing all Soviet industry: insufficient funding, chronic problems with timely deliveries of equipment, poor maintenance practices, and lack of expertise in computer technology. If Moscow is to overcome these problems, it will need to provide substantial quantities of new investment both to R&D efforts for new equipment and to the petrochemical industry for renovation and implementation of new process technologies.

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Meeting Investment Targets

In a mid-1986 speech to the Supreme Soviet, Prime Minister Nikolay Ryzhkov stated that capital investment for the development of the chemical industry in the 1986-90 plan period will increase by 50 percent compared to 1981-85. The share of this investment allocated for equipment is scheduled to rise to 56 percent compared to 45 percent in 1981-85. This implies a 13-percent average annual rate of growth for the equipment component of investment and would require 19 billion rubles compared to 10.2 billion rubles in 1981-85. Moreover, this would be only a beginning. The Deputy Minister of the Chemical Industry claimed that implementation of the chemicalization program, presumably through the year 2000, would require two or three times more investment funds than were channeled into the industry in the past 15 years.

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Simply finding the funds will be difficult enough, given the high priority of other claimants, notably energy and machine building. But Moscow will also have to come to grips with balancing the allocation of these funds between acquisition of domestic and foreign equipment and between reconstruction and new construction.

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Domestic Machinery Versus Imported Machinery.

Despite the priority that Gorbachev has accorded the machine-building sector, the Soviets cannot expect an immediate boost in supplies of chemical equipment. Implementation of plans to increase production of newly developed equipment may be too ambitious for chemical machine builders. Pressure to raise not only total output but also output of new machinery could reinforce the traditional tendency of enterprise managers to meet production quotas by continuing to produce chemical equipment that is below world standards. Indeed, the record of supplying new chemical equipment in 1986 was disappointing—fulfillment of the deliveries plan in the Ministry of Chemical and Petroleum Machine Building was lower than in 1985. [redacted]

One of the most serious constraints to improving the quality of domestic chemical equipment is an inadequate supply of corrosion-resistant metals such as titanium, stainless steel, and chromium. Military requirements for these metals generally override the needs of civilian industry. The defense industries, for example, have an unusually high degree of control over titanium consumption; nonmilitary use of titanium products must be approved by an arm of the Ministry of the Aviation Industry. Although the use of titanium products in civilian chemical equipment has grown, shortages are chronic because of the military's continuing needs for this metal for specialized applications in submarines, aircraft, and missiles. [redacted]

Chemical machine builders are also hampered by requirements to produce equipment for other sectors of civilian industry. The Ministry of Chemical and Petroleum Machine Building, for example, also produces equipment for the oil industry, and pressure to maintain oil production near current levels will probably dictate priority supplies for that industry. According to the Soviet press, recent requirements laid on plants of the ministry to produce agricultural tractors are further exacerbating shortages of chemical equipment. [redacted]

Because the problems with domestic machinery are likely to be resolved only slowly, Moscow will have to renew its reliance on Western machinery and technology considered critical to advancing the state of the art in petrochemicals.⁵ Although Gorbachev is stressing domestic production, we believe that Soviet and CEMA resources and technology cannot carry the modernization effort alone. The dominant role that Western technology played in earlier efforts to modernize the industry resulted in neglect of the domestic R&D effort. Today the relative backwardness of Soviet chemical engineering and a shortage of R&D personnel and skilled managers represent critical obstacles to progress in modernizing the industry [redacted]

The fact that the Soviets have imported Western plants even after they succeeded in developing their own processes for many petrochemicals indicates that they ultimately judged the Western processes to be technologically superior and more economical.⁶ Almost all of the major types of plastics and synthetic fibers in the USSR are currently produced with imported technology. Generally the Soviets may be able to reproduce Western technology such as a polyester fiber plant, but by the time they could do so the level of technology in the West would have

⁶ An example of the failure of domestic technology to be successfully implemented is characterized by an experimental installation for producing polyester fiber from terephthalic acid. This installation was originally scheduled for commissioning in 1973 but did not begin operation until 1976 because of inadequate process development and poor equipment design. The Soviets subsequently ordered several polyester fiber and intermediate plants based on a different process from the West. [redacted]

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Research and Development

The Soviets need to overhaul the entire R&D-to-production cycle by better coordinating research and experimental facilities with production enterprises. They also need to increase funding for basic and applied research. The Soviets are likely to have a hard time, however, changing the academic orientation of research institutes. It will also be difficult to modify the quota mentality that guides the decisions of enterprise managers and fosters resistance to innovation. The leadership must address the reluctance of enterprise management to set aside more resources for building pilot plants and other experimental installations, possibly by removing the pressure to use investment funds entirely for the maximization of output. During the first three years of the 1981-85 plan, for example, the Ministry of the Chemical Industry used less than two-thirds of the funds allocated to it for the development of pilot industrial plants. [redacted]

As a means of bringing science and production closer together and coordinating and accelerating the introduction of improved processes and products, the Soviets have begun to experiment with new organizational approaches. In December 1985 the USSR established 16 so-called Interbranch Scientific and

Technical Complexes (MNTKs) to coordinate re-search in several key industrial areas including polymers.^a The Soviets have also organized a series of scientific production associations to improve research and planning in chemical and petrochemical production associations and enterprises. However, Moscow has run into organizational problems among the participants that are hindering effectiveness. The heads of scientific production associations are not able to oversee developments from their origin in a research organization to production. Furthermore, different functional administrations within the Ministry of the Chemical Industry are taking positions at odds with each other regarding production volumes, the number of enterprise personnel, wage funds, and research to be pursued. [redacted]

^a Each MNTK will have an academic or industrial ministry institute as its nucleus and will coordinate all of the work in its area throughout the USSR. Resources are to be supplied by the State Committee for Material and Technical Supply. When new technologies are approved, the State Planning Committee will select the enterprises to use the technologies. Planners believe that this method of organizing intersector developments is simpler than organizational restructuring. For example, the development of new polymer membrane filters and technologies for the membrane separation of liquid and gaseous media is entrusted to the "Membrane" MNTK of the Ministry of the Chemical Industry. [redacted]

advanced to a new stage. According to a Soviet emigre, the technological gap between the Western and Soviet chemical industries is between 10 and 20 years. [redacted]

Because a modern petrochemical industry is crucial to advances in other key sectors of the economy—especially agriculture, machine building, medicine, construction, consumer goods, and transportation—the Soviets are likely to purchase those items of technology and equipment most needed to modernize the industry. These include advanced equipment and technology to produce:

- Polymers for the production of plastics and synthetic fibers, which would increase the quality and quantity of consumer products and industrial materials.

- Sophisticated agrochemicals, which would boost agricultural yields.
 - Membranes, which would provide greater efficiency in the processing of foods, pharmaceuticals, and caustic soda.
 - Catalysts, which would increase efficiency in oil refining and petrochemical production.
 - Ammonia—renovation of existing plants would save energy and increase output of nitrogen fertilizers.
- [redacted]

Hard currency constraints, however, will limit imports of Western petrochemical technology and equipment. The outlook for Soviet hard currency imports is bleak

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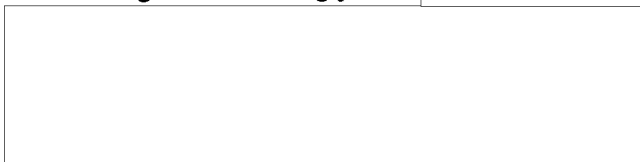


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as long as energy prices remain low. Declining earnings from oil and gas exports cost the Soviets \$4 billion in 1985 and probably cost them an additional \$3-4 billion in 1986. The Soviets have canceled, delayed, or scaled down several large chemical projects under negotiation with Western firms [redacted]

[redacted] These cutbacks will have an adverse impact on the availability of synthetic fibers and plastics for consumer and industrial goods and will cause the Soviets to continue to rely on their own less effective or

imported pesticides. Moscow has apparently reassessed its investment priorities to include fewer petrochemical facilities and recently began new talks with Western firms for constructing some new plants and modernizing several existing plants. [redacted]



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As a means of overcoming hard currency constraints, the Soviets probably will press Western firms to accept compensation in the form of plant output to pay for at least part of the Western technology that they buy.⁷ During recent meetings with Western representatives, Soviet officials claimed that hard currency limitations will probably require Western suppliers to sign barter or countertrade agreements. However, many of the petrochemicals that the Soviets would provide are in oversupply in Western markets. Success, therefore, will depend on whether the Western firms decide that the advantages of sales of technology and equipment outweigh the possibility of being saddled with products that would be hard to sell in the West. The Soviets could also increase gold sales or boost borrowing as they did in 1985 and 1986, but so far Moscow has been reluctant to become too dependent on Western lenders. [REDACTED]

New directions in Soviet foreign trade policy could stimulate an inflow of Western technology. As a result of the reorganization of the Ministry of Foreign Trade, the Ministries of the Chemical Industry and Chemical and Petroleum Machine Building now have the authority to conduct trade directly with foreign firms.⁸ The Soviets also have announced plans to form joint-venture companies, which, according to a Soviet trade official, could "revolutionize Soviet technology and expand trade."⁹ Areas of most interest to Moscow for joint ventures include chemicals for the manufacture of pesticides, plastics, and chemical fibers. Some Western businessmen, however, see the Soviet effort as just another attempt to cheaply obtain Western technology. [REDACTED]

⁷ Compensation or buyback deals allow the USSR to import Western capital goods on credit and subsequently export a portion of the production from the imported equipment to cover payment. Once the deal is paid off, however, capacity is available for direct export sales or increased domestic consumption. [REDACTED]

⁹ Although many cooperation agreements between the Soviets and Western countries can be called joint ventures, the joint-venture companies defined by the Soviets today allow ownership of up to 49 percent of the firm's capital by the foreign partner. [REDACTED]

The Soviets also hope to gain more technological expertise than in the past from Western countries through cooperation agreements that do not involve foreign equity participation. A science and technology agreement with Italy provides for the development of new processes and machinery for the production of synthetic rubber, pharmaceuticals, fertilizers, and other petrochemicals. Future joint efforts with France will probably be directed toward the development of new production processes, new applications for traditional petrochemical products, and improvements in existing processes and equipment. Moscow's dependence on Western petrochemical technology and equipment could provide opportunities for the United States to sell some of the needed items, notably technology for the production of herbicides and polymers. Renewal of a cooperative agreement for the exchange of petrochemical and chemical processing technology was recently signed with a US chemical corporation. The agreement envisages cooperation in the modernization and reconstruction of factories making polyethylene. However, there will be little or no opportunity to apply leverage since the Soviets can obtain what they need from most other Western countries and would probably treat the United States as a supplier of last resort if Washington tried to tie increased sales of technology and equipment to political or strategic concessions. [REDACTED]

Eastern Europe's Contribution. The Soviets are also attempting to increase imports of East European chemical equipment, because it is generally superior to domestic equipment and hard currency expenditures are not required. [REDACTED]

[REDACTED] the USSR identified chemical equipment as one of the areas where it expected increased contributions from Eastern Europe. A Soviet-East German protocol covering trade in 1986-90 provides for the value of Soviet imports of chemical plant and equipment to more than double compared with the previous five-year period. Czechoslovakia and the USSR have also reportedly coordinated plans for 1986-90 that call for increased deliveries of Czechoslovak petrochemical equipment. [REDACTED]

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Moscow's policy to rely more heavily on Eastern Europe for chemical machinery and technology was underlined by the adoption at the end of 1985 of the CEMA Complex Program for Scientific and Technical Progress. The principal goal is to close the technology gap with the West by developing new technologies needed for modernization. One of the major areas of this program for greater economic integration is the development of new plastic and composite materials. The Soviet Chemicalization Program also envisages increased cooperation among the CEMA members in the production and mutual delivery of petrochemical products, raw materials, and equipment.¹⁰ [redacted]

Soviet efforts are likely to be stymied, however, because these countries cannot offer the scale of support needed. Although East European chemical equipment is generally better than Soviet, many East European chemical-machine-building plants are also in need of modernization. These countries, moreover, do not have sufficient capital to expand and renovate their plants, nor do they have the hard currency to get help from the West. Diversion to the USSR of chemicals now exported to the West for hard currency would worsen the foreign exchange situation of these countries. Furthermore, pressing East European countries to increase exports of chemical machinery and products would impede other Soviet goals such as increased East European contributions to Warsaw Pact defense spending. Another problem the Soviets will have to face is the balance of trade with Eastern Europe. Because falling prices have reduced the value of Soviet energy exports, Moscow will have to accept lower imports from Eastern Europe or find new items to export to balance trade with its CEMA partners. [redacted]

Renovation Versus New Construction. Moscow's difficulties in balancing domestic and foreign equipment will be compounded by the need to decide which facilities to renovate and which to start from scratch. The former Minister of the Chemical Industry remarked in mid-1985 that "building chemical projects

¹⁰ In addition to importing East European chemical equipment, the USSR relies on its CEMA partners for a variety of finished petrochemicals. Much of this trade is covered under a CEMA specialization agreement whereby the USSR supplies Eastern Europe with energy-intensive chemicals such as methanol, ammonia, and polyethylene, and the Soviets receive less-energy-intensive products such as pesticides, pharmaceuticals, paints, dyes, and rubber chemicals. [redacted]

is complicated especially for [plants producing] small-scale chemicals and even more complicated when [renovation is attempted] at plants already in operation." Planners and enterprise managers have traditionally favored building new plants or expanding existing ones rather than renovating old facilities to avoid potential problems with new production processes and lower output resulting from the shutdown of production lines. Moreover, physical constraints often limit the accommodation of modern machinery in outdated or unsuitable buildings. Even Western countries have found that reconstruction and reequipment of large enterprises is frequently so complex that it is more advantageous to build a new plant than to adapt an old one. Soviet construction ministries have also tended to avoid renovation projects because of the lack of meaningful incentives and the labor intensive-ness involved. [redacted]

Management Problems

Reorganizing the industry's outmoded management structure is also high on Gorbachev's list of steps to improve performance. Any such reorganization, however, is apt to meet with resistance, and changes, if any, are likely to be implemented only gradually.¹¹ [redacted]

Gorbachev's replacement of the ministers with better qualified managers is a step in the right direction, but it will take time for the impact of even the best management to be felt on the shop floor. Improved management down the line and better coordination of production and distribution among the three ministries producing petrochemical products are especially needed. Enterprises need to have clear responsibility and accountability for decisions on production, supply, investment, and marketing. Giving managers more autonomy in plant operation could develop a degree of personal responsibility heretofore unseen

¹¹ Gorbachev recently described the outrageous treatment of a shop superintendent at a chemical plant in Sverdlovsk as an example of local resistance that has blocked the adoption of new ideas. The shop superintendent was "rewarded" for devising a better way to organize his workers by being expelled from the Communist Party; his status was restored only after the case appeared in *Pravda* and was examined by the Central Committee. [redacted]

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and result in higher quality output and more timely deliveries to consumers. There is bound to be resistance, however, to a reallocation of authority from the ministries to the enterprises, particularly from those whose jobs may be threatened.¹² []

As a move to reduce supply bottlenecks, the Ministry of Chemical and Petroleum Machine Building has moved to a form of self-financing, whereby enterprises will be allowed to use part of the profits they generate as they choose within general guidelines set by Moscow. However, an official of the ministry acknowledged that not all of the ministry's enterprises are ready to stand on their own without state budget support. Profitable enterprises will be required to subsidize weaker ones. Furthermore, enterprises will have no control over prices. This type of halfway measure will not contribute to the achievement of desired goals, and the ministry may be disappointed in expecting most of its enterprises to be able to generate enough internal profit to make self-financing a success.¹³ []

Adherence to contract discipline and prompt fulfillment of quotas and delivery obligations are especially important in an industry characterized by a vast list of products and numerous inter- and intra-sectoral production ties. Even minor infringements of contract obligations can upset the balance and lead to underutilization of capacity. Despite measures taken in the last several years to improve the system—such as using sales volume and contract deliveries as major indicators—enforcement of penalties for failure to meet contract obligations is generally lacking. Unless an adequate system of penalties and fines is developed, including the deduction of fines from the wages of managers or workers responsible for failing to meet contract obligations, the Soviets will continue to face production and distribution problems. []

¹² A recent article in *Pravda*, discussing results of the experiment in economic management, noted that it has not been possible to create a costcutting mechanism to overcome excessive regulation and pretty tutelage of enterprises because of the limited nature of the experiment. []

¹³ The author of a recent article in the Soviet press complained that an enterprise that is preparing for the move to self-financing has already been saddled with sharply increased and unrealistic plan targets though nothing has changed at the enterprise. Moreover, the enterprise has had to pay a penalty for stocking products that are necessary for planned production but which can only be procured well in advance of need. []

Providing additional pay for greater productivity, as well as incentives for producing top-quality output and penalties for lower quality production, has the potential for eliciting modest improvements at the enterprise level. But enterprises cannot effectively influence the quality of goods and equipment they receive until they are able to choose their own suppliers. Greater use of price supplements and reductions according to quality is only a minimal effort to link production more closely to consumer preference. Only with fundamental changes in the Soviet economic system that will force producers to be responsive to consumer demand and prices and wages to reflect this demand can inefficiencies be overcome. Also, until some form of financial responsibility is extended to organizations such as the State Planning Committee and the State Committee for Material and Technical Supply, shortcomings in their operations are likely to hamper the fulfillment of delivery plans of the enterprises. []

Labor Requirements

In trying to improve the R&D-to-production cycle, the USSR will have difficulty providing sufficient personnel with the wide variety of skills needed. More than almost any other industry, the petrochemical industry draws upon numerous specialists, with each phase of a project having its own particular manpower requirements. Major projects often require the cooperation of chemists, biologists, physicists, chemical engineers, civil engineers, electrical engineers, mathematicians, and economists. Above all, the Soviets need competent scientists and engineers to develop and implement new technologies. []

As in all of Soviet industry, an excessive number of personnel are engaged in relatively unskilled auxiliary work such as packaging, sorting, loading, unloading, and repair. Increased use of automation and mechanization would help alleviate some labor problems by decreasing the number of personnel engaged in this work. But the Soviets would still need to increase training of workers for skilled positions, particularly those with the skills to operate modern large-scale automated petrochemical plants. []

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Indicative of the major technological change in the industry has been a 170-percent increase in the value of plant and equipment (in constant prices) per worker from 1970 to 1985, compared with a 150-percent increase for the balance of Soviet industry. During the same period, however, the number of graduates specializing in chemical science from higher and specialized schools fell more than 17 percent. In the 1981-84 period, enrollments at these schools declined by more than 5 percent. These statistics do not bode well for future staffing of the scientific institutions that are to develop the technologies needed to modernize the industry. Nor is there likely to be an adequate supply of skilled labor to operate plants based on modern technology. The USSR could divert some of the scientific talent now working in military areas to civilian industry, but we do not view this as a likely response. []

Can Gorbachev's Program Succeed?

Gorbachev has yet to back his promises to modernize the petrochemical industry with concrete actions. For his program to have any chance of success, he will have to move soon on a number of fronts. Indicators of progress would include:

- Continued large increases in investment in the chemical and petrochemical industry, and in the chemical-machine-building sector. Gorbachev's call for an 80-percent increase in investment in overall machine building in 1986-90 over the 1981-85 level should include allocation of additional funds for chemical machine building.
- Further moves to replace ineffective management throughout the industry.
- Pressure on Eastern Europe to supply more chemical equipment.
- Pressure on Eastern Europe to supply more specialty chemicals—those that require a higher degree of technology. This would provide the Soviets with more high-quality pesticides, chemical additives, pharmaceuticals, and catalysts.

However, as the Soviets strive to close the technology gap with the West, Western countries, propelled by the forces of the market, will move on to newer generations of technologies, forcing the Soviets to step up technology and equipment imports or fall even further behind. []

Gorbachev is bound to make some progress in his program, but it is highly unlikely that he will come close to his goals. Adapting to new technological requirements under Soviet conditions is a slow process. Output of petrochemicals will increase, but it is unlikely that Moscow will be able to fulfill plans for production of the more sophisticated materials that it needs. Given the historical neglect of the chemical-machine-building sector, it is nearly impossible for domestic producers to overcome their backwardness any time soon, even with substantial infusion of new capital. []

Even if technology problems with domestic machinery were overcome and the Soviets succeeded in producing large quantities of modern equipment, there would still be numerous problems in organization, installation, and manning that would make it difficult to meet the needs for the quantity and quality of petrochemicals. Moreover, they could have potential feedstock supply problems in the short term, although not on the same scale as problems with equipment, management, and labor (see inset). []

The only way for Gorbachev to meet his goals for technological innovation over the medium term will be to continue dependency on the West. Indications that Gorbachev is moving in this direction would include:

- The signing of contracts for petrochemical projects under negotiation or that have been delayed or canceled.
- The signing of contracts with Western firms for modernizing existing petrochemical complexes.
- A marked step-up in imports of petrochemical products.
- Changes in Soviet conditions for Western businessmen that would facilitate imports of Western technology through joint ventures and direct trade ties between Western and Soviet firms. []

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Petrochemical Feedstocks

The Soviets have sufficient hydrocarbon resources for petrochemical production. Oil used for feedstocks will have to compete with fuel uses, but only about 2 percent of total oil output goes into the production of petrochemicals. Natural gas feedstocks are more than ample, and petrochemical use accounts for only about 10 percent of domestic gas consumption. Nevertheless, shortages of associated gas are causing feedstock problems in certain regions, necessitating transport of feedstocks from other areas. Because of limited storage facilities for natural gas, we can expect continued supply interruptions during extremely cold weather. Moreover, shortfalls of feedstocks from oil refineries have idled and caused below-capacity output at certain petrochemical plants. Increased availability of gas condensate along with rapidly growing gas output could be relied upon more heavily in the future, but unless construction of gas-processing facilities commands more priority from planners, much of this valuable raw material will be wasted.

Increased orders toward the end of the five-year plan period might indicate a realization on the part of the Soviet leadership that modernization cannot proceed on the basis of domestic technology alone. Although we cannot predict how quickly or deeply Moscow will renew its dependence on the West, Gorbachev has a strong incentive to provide for a modern, healthy petrochemical industry both because it provides the basis for technological advances in other sectors of the economy and because its products can be used to bolster the USSR's hard currency earnings (see inset on page 18).

The Cost of Failure

Failure to make substantial progress in modernization of the petrochemical industry would adversely affect Gorbachev's entire program. Lack of success in improving management efficiency and in implementing

effective incentive programs for petrochemical workers would lower discipline and lead to continued waste and mismanagement. Failure to supply new technology and equipment to the petrochemical industry would hinder efforts to conserve energy and raw materials and would slow the economywide modernization effort. Shortfalls in the amount and assortment of petrochemicals would have a particularly detrimental effect in a number of areas. Specifically:

- A slowdown in the development of new materials would retard progress in machine building, construction, and the automotive industry.
- Inadequate supplies of modern fertilizers and pesticides would have an adverse effect on crop yields and would jeopardize the goals of the Food Program. This would exacerbate the difficulty of choosing between food and machinery imports.
- Lack of steadily increasing quantities of petrochemicals for the oil industry would jeopardize the goals of the Energy Program by retarding enhanced oil recovery and drilling operations.

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Increased imports of certain types of petrochemical products and technology would be needed to prevent shortages, putting an additional strain on hard currency resources. In spite of the lipservice paid to the consumer, we judge that Gorbachev would opt to supply priority sectors such as the military, energy, and agriculture before devoting scarce petrochemical products to consumer amenities.

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Potential for Increased Exports

Petrochemical exports to the West are likely to grow both as a result of direct sales and as compensation for purchases of Western equipment and technology. Buyback or compensation agreements have provided a major stimulus to Soviet petrochemical exports to the West, giving Moscow a readymade market for such products as ammonia, methanol, polyethylene, and xylenes. With the exception of some chemicals such as ammonia, the volume of exports is likely to remain small. If the current soft markets for these products continue, the Soviets might undercut prices to make sales. Western countries, however, are likely to respond with restrictions such as those placed on US imports of Soviet urea, which were judged to be selling at less than the cost of production in 1986. Nevertheless, by the end of the decade the Soviets could be earning nearly \$680 million annually in hard currency from sales of ammonia, nitrogen fertilizers, and methanol, 40 percent more than in 1985.

Soviet exports of ammonia soared from 88,000 tons in 1975 to nearly 2.9 million tons in 1984, accounting for about one-third of total world trade. About four-fifths of Soviet ammonia sales are for hard currency. Expansion of ammonia and urea capacity, albeit at a slower rate, is likely to continue for at least the next five years, and the Soviets will continue to dominate the market for the foreseeable future. As much as 3.5 million tons of ammonia could be available for export to the West in 1990. At current prices (\$100 per ton), potential hard currency earnings could reach \$350 million annually.

About one-fifth of the 5 million tons of nitrogen fertilizer products exported in 1985 went to non-Communist countries. Urea has accounted for most

of the increase in recent years, but because of the relative slowdown in urea capacity expansions and the increase in domestic deliveries, urea exports are expected to stabilize or increase only slightly. In 1990 the Soviets could have 2.1-2.6 million tons of nitrogen fertilizer available for export to the West. At the 1987 price of urea (\$100 per ton), potential annual hard currency earnings could reach \$210-260 million.

Soviet exports of methanol in 1985, 710,000 tons, were nearly three times those of 1983. The surge in exports reflects the addition of two 750,000 ton-per-year methanol plants purchased from the United Kingdom. Barring an unlikely sharp jump in domestic consumption, the exportable surplus of methanol could increase to about 1 million tons in the late 1980s, with about three-fourths going to the West. At today's prices (\$85 per ton), potential annual earnings could be about \$65 million. As a result of the startup of two large xylene complexes, the USSR became the world's largest exporter of xylenes in 1984, and exports exceeded 350,000 tons in 1985, three-fourths of which went to hard currency countries.

The Soviets are also committed under compensation agreements to export certain plastics and intermediate chemicals to the West. Although volumes now exported generally are small compared to West European production, exports of some products, such as polyethylene, have already caused disruption in West European markets as a result of Soviet underpricing. The Soviets plan to use most of the output domestically once the payback periods are completed, but some of these materials probably will continue to be available for export, intensifying the already competitive nature of the West European market.

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